Lonestar Power Analysis and Comparison

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Lonestar Microtape Mass Storage Peripheral
Power Analysis Table of Contents

SECTION 1

INTRODUCTION

1.1 DESCRIPTION

The LONESTAR MICROTAPE is a portable battery operated mass data or program storage device. Is is designed to operate with the LONESTAR Advanced Language Calculator or any device which supports the LONESTAR Intelligent Peripherals Bus structure, timing, and protocol.

Up to eight Microtapes are supported by the LONESTAR Intelligent Peripherals Bus (IPB) and each may have open or closed files at any one time. Each Microtape is designed to support a nominal data transfer rate of 8 Kilo-baud in a reliable fashion with the Bus Master (the ALCC) Reading or Writing to a maximium of only one of the eight possible Microtape Devices at a time.

1.2 PERFORMANCE OBJECTIVES

Performance Objectives directly relating to Power Analysis include:

*Must Read and Write at 8 Kilo-baud (K=1024) +/- 25% Tolerance (This implies that a tape written at 8K baud when the battery is low could yield a Read Rate of
8Kbaud x (8/6) x ((8*1.25)/8) = 13.3K baud
if the tape is read back when the system voltage is at the 1.25 x Normal range. In real life operation, our choice of power supplies will prevent us from ever seeing more than a 12K baud read rate.)

*Must be able to operate from two sources of system power: Battery and a DC Charger/Adapter.

*Must operate reliably with soft (recoverable) error rates less than 1 bit in 10 E+09 and with hard (non-recoverable) error rates less than 1 bit in 10 E+12. These error rates are compatible with industry standards and accepted data error rates.

*Must be able to operate reliably independent of voltage source (Battery or DC Adapter/Charger). This implies the capability to accept a very wide range of raw input voltages and deliver a consistant, steady output voltage.

*When in a portable mode of operation, the system must be able to utilize Battery Power as efficiently as possible.

*Must provide the user with some sort of "Low Power" indication. This may be in the form of an audio or a visual signal. After informing the user, the system must be able to continue the current operation properly for a reasonable length of time and communicate with the IPB Master.

*After the Battery Voltage has decreased to an unacceptable level for Read or Write Operations, then the Microtape must still be able to return error messages to the Bus Master for a reasonable length of time and it must NOT (!) interfere with other devices on the IPB. This means that if the Batteries die, then the Microtape must NOT (!) pull the IPB Data and Control lines low for a reasonable length of time.

*The Power Supply must do all of the above wonderful things in an inexpensive, cost efficient manner.

SECTION 2

Operating Modes

2.1 STANDBY OPERATION

After Power is applied to the system, the Microtape Processor executes a "power up clear" routine. All system components are then put into a very low power consumption (sleep) mode as they wait on the IPB Master to initiate a message.

When a new Message comes across the bus (the IPB signal"BAV" falls low), the Processor wakes up and determines if it is "Me". This might be device #00 or one of the eight designated Microtape device addresses. (For further information on the operation and Protocol of the IPB, refer to the "LONESTAR Intelligent Peripherals Bus Structure, Timing, and Protocol Specification: Revision 2.0.) If the message is addressed to "me", then the Microtape will accept the rest of the Command Messsage. If the Message is not for "me", then the Microtape goes back to "sleep".

2.2 READ/WRITE OPERATION

If the Message is addressed to "Me", then the Microtape remains in the Wake-Up Mode and generates the appropriate response back to the Bus Master. If this Response involves an information transfer to or from the Microtape Wafer, then another level of power consumption is entered. The Microprocessor turns on the Motor Control Logic, Sensor Logic, and the Analog Read/Write Circuitry and performs the appropriate function.

2.3 LOW BATTERY OPERATION

Low Battery Operation occurs when the Microtape is in a portable mode of operation and the Batteries lack the power to adequately operate the motor. In such an operational mode, the objectives of the Microtape are to use a minimum amount of power and to not "pull the bus down". Pulling the bus down would prevent information from being transferred between IPB devices and probably frustrate the user. A user would suddenly find that his system would not work because some device (probably) ran low on battery power ("but which one?", he might say). By staying "up and running" after the motor is disabled for some reasonable length of time, the user can be notified of a low battery but not necessarily have to change batteries right then. This is especially useful where two or more portable peripherals are in use with the Bus Master. One such scenario would involve an ALC, two Microtapes and a modem. Just because one Microtape has low batteries, the rest of the system is not down.

Ideally, the low battery mode of operation should "suck the battery dry", if non-rechargeable and operate down to a low voltage if rechargeable. The ability to open a File would be severely curtailed and there should be enough power left in the batteries to finish any file operation, Read or Write.

SECTION 3

Objectives and Performance

3.1 POWER SUPPLY OBJECTIVES

The Power Supply selected for the Microtape was designed to yield maximum performance from a wide variety of input voltages (from 1.5V to 6.5V) and operate properly from two voltage sources: a Battery and/or a DC Adapter/Charger. Consisting of two parts, a +5V System Supply and a +4V Motor supply, the dual switching regulator yields maximum operational performance as well as very high efficiency (78%, typically).

Maximum Motor On Time was a very important consideration in the design scheme and a "buck"(regulate down) configuration was chosen. The Buck Regulator will regulate a 4.0V output voltage from an input voltage of 4.08V at a 71 Ma load condition. Careful component selection to optimize efficiency and cost assures us that the motor will operate properly down to a battery voltage of 3.88V and a motor voltage of 3.8V (V(m)-5%). Below this battery voltage, read operations are still possible but are not specified for write operations.

The System +5V Supply utilizes a "boost" (regulate up) configuration. The regulation characteristics of a SMPS combined with a Germanium commuting diode yielded very high performance.

3.2 MICROTAPE POWER SUPPLY REAL TIME OPERATING PERFORMANCE

The Real Time Operating Performance (RTOP) of the Microtape Power Supply may be viewed as a group of performances from several different power sources. The Microtape has two sources of power for the system: a DC Adapter/Charger (6V Regulated DC) and/or a Battery. The Microptape operates off of the DC Adapter/ Charger Voltage if the Adapter Jack is plugged into its socket. otherwise, the Microtape operates off of 4 "AA" Batteries.

The Real Time operating performance of the Microtape is composed of four separate blocks of operation: Standby, Read, Write, and Low Battery Operation modes.

The maximum portable operation On Time Window is defined by the

Standby Operation power consumption. Within this window, many events can occur which will decrease theoretical battery life. The way these operations interact with each other will be discussed with more detail in section 5.

Several parameters are of interest when discussing the power supply. These include: battery life, motor on time, system +5V on time, data error rate, regulator efficiency, and the battery issue (Ni-Cad rechargeable versus Alkaline non-rechargable) parameters. Each of these parameters may be discussed separately, but all are a function of real time operating conditions. In a later section, we will see how the separate modes mesh together in typical operation scenarios to yield typical parameters of interest (battery life, motor on time, system +5V on time, data error rate, regulator efficiency, and battery data (Alkaline/Ni-Cad)).

3.2.1 STANDBY MODE

The Microtape awaits commands from the Bus Master in the Standby Mode, the most common Operational Mode. Average power consumption for this mode of operation is about 0.25 Ma. When a new message is placed on the IPB, the 70C20 wakes up and determines if it is adressed to "ME". If so, the 70C20 executes the appropriate command and goes back to sleep. Power consumption when the 70C20 is operating and "Awake" averages 4.5 Ma. with a maximium of 6.5 Ma. The proportion of "Awake" time versus "Asleep" time is very small for the vast majority of applications and programs. In a later section, some scenarios are presented to illustrate this.

3.2.2 READ OPERATION

When the Microtape is commanded to perform a Read or a Write operation, the Motor Voltage Regulator is turned on. As the Motor initially starts, the inrush current is around 210 Ma. This very short duration current levels off to approximately 8 Ma in a no load (no wafer inserted) condition. A lightly loaded Microtape Drive would consume an additional amount of power.

In motor test on March 6, we found that the as one increased the length of the tape on the wafer, that current consumption did not increase linearly as a direct function. Our testing showed that as one increased the length of the tape in the wafer, actual current decreased. For a 5' wafer, current consumption averaged 27 Ma. The same testing showed that a 50' wafer averaged 22 Ma. under the same conditions. The major contributor to increased current consumption appeared to be poor wafer quality. This occured in one particular 20' wafer. This wafer averaged 42 Ma of power consumption and audibally sounded "bad". We also compared the performance of the direct drive motor

and the belt drive Exatron Stringy and found a much more consistant performance from the direct drive (TI choice) method. The Exatron Stringy averaged from 140 to 230 Ma. of no load current, but displayed the same relative increase of current when wafers of 5' to 50' were inserted. Again, the 50' wafers consistantly consumed less power than shorter wafers. Upon measurement and calculation, we found that the average current for all wafers tested with our direct drive motor was 25 Ma. The maximum amount of power consumed by a type of wafer was 27 Ma by the 5' wafer. In real time operation, we determined that the length of the wafer would not be the total driving factor behind the power consumption of the motor. The driving factor would also be a function of the wafer drag, degree of Wafer insertion and Microtape/Wafer tolerances.
For the rest of this paper, we will talk about an average supply currnt of 25 Ma to the motor and consider that a 10 Ma current margin will be quite sufficient to cover any additional tape drag current consumption. (In our testing, only one wafer out of 52 required more power than this to drive it. That wafer was audibally failing.) The 35 Ma motor current is 40% more than what is required, so when we come up with a "Motor On" time, we will use the 35 Ma figure as our worst case value. The 35 Ma figure implies a worst case Motor On Time reduction of 28.5% compared to typical performance. We will also talk about a special case where we intentially increase the average wafer load current soas to reduce wafer-to-wafer speed variations due to drag, tolerance, and insertion differences.

The average no-load power consumption of the Microtape is not that important since we envision the user changing Wafers only when the motor is off.

The Analog Read/Write circuitry is also turned on for use in Read Mode Operation. It consist of two Op Amps, four Comparators, and discrete support components.

Power consumption for the Read Operation Mode is typically 36.6 Ma. and is a maximum of 58.6 Ma.

3.2.3 WRITE OPERATION

Write Operation is similiar to Read Operation with the addition of one function: the 70C20 Processor also writes information to the tape instead of just reading information. This implies that the Magnetic Tape Head is energized and a Write Current of approximately 8 Ma. is supplied. Power Consumption for the Write Mode is typically 46.4 Ma. and is a maximum of 69.5 Ma.

3.2.4 LOW BATTERY PERFORMANCE

Low battery operation occurs in a portable mode of operation when the battery has discharged to a point where the output Motor Voltage is too low to drive the motor properly. Indication of this voltage level will have occured earlier and the appropri-ate actions reguarding status modification and allowable file operations will also have occured.

Whether the motor is running is not the only critical performance issue for the Low Battery Mode. An important function of the Microtape is to not pull down the IPB when the battery is low and to provide error indication when the Microtape is addressed. This prevents one device from dis-abling the entire system because of low batteries for a reasonable length of time. The Microtape should be able to operate long after Read/Write Operations are disabled. Tests have shown that a 200 Hour figure is not unreasonable and that 250-300 Hours is probably a more accurate figure.

SECTION 4

Rechargeable/Non-Rechargeable Batteries

4.1 ALKALINE (NON-RECHARGEABLE) BATTERY PERFORMANCE

The Power Supply Topology selected was tested with a number of different battery sets. When tested, the load was well in excess of expected operating values and yielded a very acceptable performance. We found that a set (4-"AA") of batteries yielded approximately 12 to 15 Hours of Motor On time with a load of 71 Ma for the Motor circiut and 10 Ma for the System +5V circuit. An additional 60 Hours of +5V System Power was obtained at a 4 Ma Load. These levels are almost three times that of the Microtape average power consumption. These current-load levels were chosen because of our belief that a moderate to heavy drag 50' wafer would consume 70 Ma of power and a 10 Ma load level for the +5V System Power would provide a compromise value for a 70C20 load current. These initial assumptions, though wrong, turned out to actually be an advantage in that they allowed a number of different tests to be performed in a small amount of time. Longer term test (done last) verified the performace illustrated by the earlier short term test and were, if anything, much more efficient in their use of battery power.

From the testing done with Alkaline Batteries, we feel that an accurate Motor On (Read/Write) time is 32-35 hours with a 36 Ma load. Under AVERAGE TAPE CONDITIONS, this figure is between 42 and 51 hours. A detailed test of this estimate was accomplished during the week of march 8-15. Low Battery time after Read/Write operations have been disabled is between 200-300 hours using the expected Sleep Mode Power values.

The battery tests we have done have all been continous. When the motor was turned on, it remained on until it was at the "low voltage" point. In real world operations, it will not do this. The motor will be turned on for a maximum of 133 seconds (for a 50 foot wafer which makes two complete loops of the tape) and will typically be on for 30 seconds (for a 25 foot wafer which which makes alternate "searches" and "next record" operations). The battery will have time in between "motor on times" in which to "recover". This recovery time allows the battery to "self charge", thus extending battery life. If one has a flashlight, this effect is easily observable. After a "long" period of time, a partially drained flashlight will turn on with the luminosity of fairly new batteries. After a short space of time, the luminosity will lessen to a level reflecting the actual power and voltage level of the battery. We can use this "Flashlight" effect to increase the actual operating life of the Microtape batteries substantially as that the motor only lightly loads the batteries and discharges of the batteries will usually occur over a period of months. We do not consider this increased battery performance time in our "Motor Time On" figure because it is very user dependent. This "flashlight effect" also has a negative side. the decrease in the apparent energy level of the battery is much more rapid than that of ordinary continous discharge. This could produce a situation in which we were writing to the tape and it experienced a rapid slow-down. For this reason, we monitor the "Low Battery" line before Read and Write Operations to detect this type of effect. This prevents erroneaus operations from apparentely "good" batteries.

The batteries will not provide adequate +5V System voltage if the initial battery voltage is too low. It takes approximately 2.5V of battery power to get the +5V System Power up. This could be a real disadvantage if it were not for the "battery effect". The initial surge from the battery should be more than sufficient to start the "boost"regulator and provide proper power. If the turn on voltage surge is insufficient, then external devices will provide enough power through the data and control lines on the IPB. This is a time constant effect. Even with very low batteries in the system, a portion of the +5V power will come from them and the load on the IPB will be reduced.

4.2 NI-CAD BATTERY (RECHARGEABLE) PERFORMANCE

The Power Supply Topology was tested with rechargeable Ni-Cad batteries also. Similiar performance figures reguarding efficiencies, load response times and on/off times were obtained. One major difference was observed, however. The "Motor On Time" was significantly higher, proportionately, for Ni-Cads than for Alkalines. We measured a total on time of around 17 hours (versus 40 hours for the alkaline) and the percentage of "MOT" for Ni-Cads versus Alkalines seemed too high (at 42%). This ratio is much higher than their relative power capacities indicate. Some examination showed that this may be attributed to the discharge characteristics of Alkaline versus Ni-Cad batteries. Once discharged to the "Low Battery" condition, however, Ni-Cad batteries exhibited poor long term performance. The batteries quickly discharged to a very low voltage level.

The additional cost associated with Ni-Cad batteries do not seem to justify the increase in performance versus Alkaline batteries. We expect to be able to yield a final Motor On Time value of 45-55 Hours with the Alkaline batteries and could possibly get 18 Motor On Time hours for the Ni-Cads. This figure, although significant, does not take into account the self discharge time of the Ni-Cads nor does it take into account the relative lifetime of the rechargeable batteries. The average to above-average user would probably be better off with Alkaline batteries.

Ni-Cad batteries become very attractive if we do any of three things, however. These include:

1. Utilizing a TMS 7040 (NMOS) Processor in place of the current TMS 70C20 (CMOS) Processor.
2. Not duty-cycling the BOT/EOT or Write Protect Sensors.
3. Running the Front Panel LED whenever the Microtape is performing an operation associated with the IPB.

4.3 PERFORMANCE COMPARISONS

It is very difficult to talk about strict performance comparrisons between Alkaline and Ni-Cad batteries. It is essentially a question of whether the cost-performance lifetime of Alkaline batteries is superior to cost-performace lifetime of Ni-Cads. Additionally, is it worth bumping the SRP of the Microtape up to include Re-Chargeable batteries? In the next section, we will obtain some of the answers to these issues.

SECTION 5

REAL TIME PERFORMANCE

Microtape performance can be divided up into several different areas: operational mode power consumption, real time operating scenarios, and real time battery lifetime.

5.1 OPERATIONAL MODE CURRENT CONSUMPTION

The Microtape may be divided up into several discrete sections of logic and circuitry. Each section has its own level of current consumption and operating characteristics. Refer to the appendix for the schematic and sectional groupings for further information.

5.1.1 ON STATE CURRENT CONSUMPTION

SECTION	TYPICAL	MAXIMUM	
Read/Write Circuitry (on)	2220	3520	Microamps
Read/Write Circuitry (off)	0.1	0.1	"
Sensor Circuitry (Continously On)	22000	23000	"
Sensor Circuitry (duty cycled)	52	60	"
Sensor Circuitry (off)	0.1	0.1	"
TMS 70C20 (awake - 3.58 MHz)	5500	6500	"
TMS 70C20 (asleep)	5	10	"
IOBC Chip (active)	200	500	"
IOBC Chip (in-active)	6	250	"
IPB Pullup Resistors +	83	1667	"
Misc. Leakage current	30	50	"
Switching +5V Sys. Supp.(bias)	135	150	"
+5V System SMPS Inefficiency	20	22	%
+4V Motor SMPS Inefficiency	20	22	%
Motor Current (off)	25	50	Microamps
Motor Current (Load #1)	20000	____	"
Motor Current (Load #2)	25000	____	"
Motor Current (Load #3)	30000	____	"
Motor Current (Load #4)	35000	____	"
Motor Current (Load #5)	40000	____	"
Motor Current (Load #6)	45000	____	"
Front Panel Yellow LED	20000	24000	"

+The wide range (minimum to maximum) of current consumption reflects the wide variation of IPB operating conditions.

Each of the four modes of operation consume different levels of current in the Microtape. We list them here and show the relative power level each subsystem component operates at.

5.1.2 CURRENT CONSUMPTION BY OPERATING MODE

Each operating mode's power consumption profile is composed of a group of section power consumption profiles. We analyze them here.

5.1.2.1 STANDBY OPERATION MODE POWER CONSUMPTION

SECTION	TYPICAL	MAXIMUM	
R/W Circuitry	0.1	0.1	Microamps
Sensor Circuitry	0.1	0.1	"
TMS 70C20 (asleep)	5	10	"
IOBC Chip (inactive)	6	250	"
IPB Pullup Resistors	83	1667	"
Motor Voltage (off)	25	50	"
Misc. Leakage Currents	30	50	"
	------	------	
Total	144.2	2027.2	Microamps
+5V SMPS Inefficiency	20	22	%
+5V SMPS Regulator Inefficiency*	36.1	571.8	Microamps
+5V SMPS Idle Current	135	150	"
	------	------	
Microtape Standby Total	315.3	2749	Microamps

*This current for portable operation mode. In a non-portable mode, the DC Adapter will provide power and current consumption for the Microtape is not critical for the battery.

5.1.2.2 READ OPERATION MODE POWER CONSUMPTION

SECTION	TYPICAL	MAXIMUM	
R/W Circuitry (on)	2220	3520	Microamps
Sensor Circuitry (on - duty cycled)	52	60	"
TMS 70C20 (awake)	5500	6500	"
IOBC Chip (active)	200	500	"
IPB Pullup Resistors	83	1667	"
Misc Leakage Currents	30	50	"
Motor Current	25000	35000	"
	------	-----	
Total	33085	47297	Microamps
+5V SMPS Inefficiency	20	22	%
+5V SMPS Regulator Inefficiency*	2021.3	3468.4	Microamps
Motor Voltage Inefficiency	20	22	%
Motor Voltage Current Inefficiency	6250	9871.8	Microamps
+5V SMPS System Voltage	135	150	"

	TYPICAL	MAXIMUM	
Microtape Read Current Total	41491.3	60787.2	Microamps

NOTE: For Non-Duty Cycled Sensors, add 27500 Microamps typically and 29500 Microamps Maximum.

5.1.2.3 WRITE OPERATION MODE POWER CONSUMPTION

SECTION	TYPICAL	MAXIMUM	
R/W Circuitry (on)	2220	3520	Microamps
Write Head Current	8000	9600	"
Sensor Circuitry (on - duty cycled)	52	60	"
TMS 70C20 (awake)	5500	6500	"
IOBC Chip (active)	200	500	"
IPB Pullup Resistors	83	1667	"
Misc Leakage Currents	30	50	"
Motor Current	25000	35000	"
Total	41085	56897	Microamps
+5V SMPS Inefficiency	20	22	%
+5V SMPS Regulator Inefficiency*	4021.3	6176.1	Microamps
Motor Voltage Inefficiency	20	22	%
Motor Voltage Current Inefficiency	6250	9871.8	Microamps
+5V SMPS System Voltage*	135	150	"
Microtape Read Current Total	51491.3	73094.9	Microamps

NOTE: For Non-Duty Cycled Sensors, add 27500 Microamps typically and 29500 Microamps Maximum.

5.1.2.4 LOW BATTERY OPERATION++

SECTION	TYPICAL	MAXIMUM	
R/W Circuitry	0.1	0.1	Microamps
Sensor Circuitry	0.1	0.1	"
TMS 70C20 (asleep)	5	10	"
IOBC Chip (inactive)	6	250	"
IPB Pullup Resistors	83	1667	"
Motor Voltage (off)	25	50	"
Misc. Leakage Currents	30	50	"
Total	144.2	2027.2	Microamps
+5V SMPS Inefficiency	20	22	%
+5V SMPS Regulator Inefficiency*	36.1	571.8	Microamps
+5V SMPS Idle Current	135	150	"
Microtape Low Battery Mode Total	315.3	2749	Microamps

++This mode is identical in current requirement to that of the "Standby Mode". The primary difference is in the source of system power for the Low Battery Mode and the fact that operations are restricted for this mode.

5.1.2.5 CURRENT CONSUMPTION SUMMARY

Current consumption operations may be summarized as follows:

OPERATION	TYPICAL	MAXIMUM	
Standby Mode	315.3	2749	Microamps
Read Mode	41491.3	60787.2	"
Write Mode	51491.3	73094.9	"
Low Battery Mode	315.3	2749	"

5.2 REAL TIME OPERATING SCENARIOS

Real Time performance can only be understood by understanding the application, or scenario, that the Microtape is to be used in. For that reason, we will postulate several scenarios of interest and determine an "on time" for each scenario. From this total "on Time", we will determine a "Motor On" and a "Battery" lifetime.

The issue of Alkaline versus Ni-cads should also be resolved through this analysis as well.

The target scenarios we will use are based in part on those of the 'November' Critical Design Review for the Advanced Language Calculator. These scenarios include: the scientific/student user (1st penetration), the business and professional user, and the "learn BASIC" user.

Due to the extensive power suply testing, we have some fairly good figures for the total Motor On Time and for the Available Window Time. A total Motor On Time of 42 Hours is fairly conservative and a total Available Window Time of 300 hours is reasonable. (The Available Window Time is the time in which Read or Write Operations are allowed without exceeding system tolerances.) Battery Shelf Time (the time where the battery is in the Microtape but not on) is conservatively rated at one year.

Sumarized here are the scenario usage parameters from the "Microtape Power Analysis".

	HOURS PER DAY	MOT DUTY CYCLE	AVERAGE DAYS/ WEEK
Student (typ)			
Student (heavy)			
Scientific (typ)			

Scientific (heavy)
Buss./Prof.(typ)
Buss./Prof.(heavy)
Teacher (typ)
Teacher (heavy)
Real Est.Agent(typ)
Real Est.Agent(hvy)
Real Est.Agent(vhvy)
Ins. Salesman (typ)
Ins. Salesman (hvy)
Ins. Salesman (vhvy)
"Learn BASIC" (typ)
"Learn BASIC" (hvy)
Maximal Usage (typ)
Maximal Usage (hvy)
Maximal usage (vhvy)

5.3 USE SCENARIOS POWER ON TIMES WITH BATTERY LIFE VALUES

Microtape On Time while operating off batteries is a very important issue in analyzing the real time performance. Earlier, we stated that a conservative Microtape Motor On Time was 42 hours and that a conservative Available Window Time was 300 hours. The Motor On Time may be traded for Available Window Time for those applications requiring large amounts of Standby Operation Time. For each hour of Motor On Time given up, we may roughly obtain an additional 120 hours. (The ratio between Read and Write times is approximately 4 to 1.) With this tradeoff in mind, we can now arrive at some total system on time hours assuming total battery (portable) operation for typical and heavy applications. For purposes of analysis, we ignore the "flashlight effect".

Additional tradeoffs can also be made with Front Panel LED Time, Non-Duty Cycled Sensor Time, and Motor On Time. One (1) second of Motor On Time (considered as 80% Read and 20% Write Operations with the Motor operating) may roughly be traded for:

*1.6 seconds typically (2.1 seconds maximum) of continous, non-cycled sensor time.

*2.2 seconds typically (2.6 seconds maximum) of Front Panel LED Time.

5.3.1.1 TYPICAL/HEAVY USE BATTERY LIFE WITH AVERAGE MICROTAPE POWER CONSUMPTION

USE SCENARIO	MOT* Typical	STANDBY* Typical	BATT** LIFE Typical	MOT* Heavy	STANDBY* Heavy	BATT** LIFE Heavy	
Student	0.18	4.32	206.0(wk#)	0.56	11.44	67.9(wk#)	Hours
Scientific	0.20	4.75	187.7(wk#)	0.62	12.58	61.4(wk#)	"
Teacher	0.26	3.74	152.8(wk#)	1.20	18.80	32.8(wk)	"
Real Est. Agent	0.36	19.64	85.0(wk#)	1.06	31.94	33.5(wk)	"
Insur. Salesmen	0.40	4.60	101.5(wk#)	0.80	19.20	46.4(wk)	"
"Learn BASIC"	0.36	4.64	111.6(wk#)	2.34	30.16	17.2(wk)	"
Maximal Usage	0.68	41.82	43.3(wk)	3.06	39.44	13.1(wk)	"
AVERAGE USAGE	0.35	11.93	99.0(wk)	1.38	23.37	28.3(wk)	Hours

*Hours per week of Operation
**Total Number of Weeks of Operation per set of batteries
#Weeks of Operation, but probably limited by the 1 year battery life
NOTE: Assume Motor On Time =42 hours, Available Time Window =300 hours, and 1 MOT hour = 120 ATW hours

5.3.1.2 TYPICAL/HEAVY USE BATTERY LIFE WITH MAXIMUM MICROTAPE POWER CONSUMPTION

USE SCENARIO	MOT* Typical	STANDBY* Typical	BATT** LIFE Typical	MOT* Heavy	STANDBY* Heavy	BATT** LIFE Heavy	
Student	0.18	4.32	83.9(wk#)	0.56	11.44	29.1(wk)	Hours
Scientific	0.20	4.75	75.9(wk#)	0.62	12.58	26.4(wk)	"
Teacher	0.26	3.74	72.5(wk#)	1.20	18.80	15.2(wk)	"
Real Est. Agent	0.36	19.64	25.8(wk)	1.06	31.94	12.7(wk)	"
Insur. Salesmen	0.40	4.60	50.9(wk)	0.80	19.20	18.9(wk)	"
"Learn BASIC"	0.36	4.64	54.5(wk#)	2.34	30.16	8.4(wk)	"
Maximal Usage	0.68	41.82	12.5(wk)	3.06	39.44	6.4(wk)	"
AVERAGE USAGE	0.35	11.93	35.7(wk)	1.38	23.44	12.8(wk)	"

*Hours per week of Operation
**Total Number of Weeks of Operation per set of batteries
#Weeks of Operation, but probably limited by the 1 year battery life
NOTE: Assume Motor On Time =28.5 hours, Available Time Window =35 hours, and 1 MOT hour = 24.5 ATW hours

5.3.1.3 VERY HEAVY USE BATTERY LIFE WITH AVERAGE MICROTAPE POWER CONSUMPTION

USE SCENARIO	MOT* Very Heavy	STANDBY* Very Heavy	BATT** LIFE Very Heavy	Hours
Real Est. Agent	3.24	56.76	12.0(wk)	"
Insur. Salesmen	2.20	52.80	16.9(wk)	"
AVERAGE USAGE	2.72	54.78	14.0(wk)	Hours

*Hours per week of Operation
**Total Number of Weeks of Operation per set of batteries
NOTE: Assume Motor On Time =42 hours, Available Time Window =300 hours, and 1 MOT hour = 120 ATW hours.

5.3.1.4 VERY HEAVY USE BATTERY LIFE WITH MAXIMUM MICROTAPE POWER CONSUMPTION

USE SCENARIO	MOT* Very Heavy	STANDBY* Very Heavy	BATT** LIFE Very Heavy	Hours
Real Estate Agent	3.24	56.76	5.4(wk)	"
Insur. Salesmen	2.20	52.80	6.9(wk)	"
AVERAGE USAGE	2.72	54.80	6.0(wk)	Hours

*Hours per week of Operation
**Total Number of Weeks of Operation per set of batteries
NOTE: Assume Motor On Time =28.5 hours, Available Window Time =35 hours and 1 MOT hour = 24.5 ATW hours

5.3.2 EFFECTS OF PORTABLE VERSUS NON-PORTABLE OPERATION

It is dificult to give a flat rate ratio for the percentage of portable versus non-portable operation. Some general guidelines might be:

*In situations where large blocks of data are being manipulated, large block visual display is also probably occurring. For Video or Data Communications peripherals, there will probably be external power nearby to tie into. Therefore, for large Microtape usage operations, there will probably be external power nearby. (It is probable that the amount of information being transferred is directly proportional to the probability of external, nearby power.)

*Environmental operations of the Microtape are pretty much defined by the Microtape Wafer and will not, therefore, adversely affect the battery performance.

*TI will eventually offer a Power Peripheral or a Power Distribution box which will significantly increase battery lifetime.

From the above guidelines, I think it very conservative to state that the battery life will roughly be extended by a factor of two. With the extremely tolerant voltage regulation section, there are many real world power sources to tap as well.

5.4 RECHARGABLE VERSUS NON-RECHARGEABLE BATTERY ISSUE REVISITED

With the battery life being limited more by its' shelf life than by its' discharge characteristics, it becomes very probable that the Alkaline battery is a superior (and cheaper) choice.